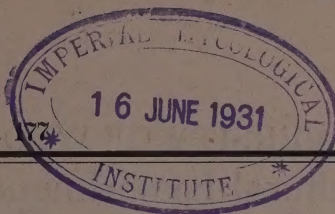


Ward, S. S.
BULLETIN NO. 177

16 JUNE 1931

APRIL, 1931



UNIVERSITY OF WYOMING AGRICULTURAL EXPERIMENT STATION



Bacterial wilt causes thinning out of alfalfa stands.

Bacterial Wilt of Alfalfa

Bulletins will be sent free upon request.

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BACTERIAL WILT OF ALFALFA

By J. S. WIAINT

INTRODUCTION

Alfalfa is Wyoming's most important crop. In 1929 nearly 380,000 acres were grown in the state. The estimated yield of 806,000 tons was valued at \$8,060,000. Any condition which increases the cost of production or lowers the yield of alfalfa affects a large portion of the farmers and ranchers of this state.

For the past few years reports have been made of alfalfa losses in the irrigated regions. Because of this a field survey of alfalfa in Wyoming was begun in the spring and summer of 1930. The purpose was to determine the factors responsible for these losses* and to obtain any information that might be of value in reducing or preventing them.

ALFALFA SURVEY OF 1930

Several hundred fields were examined in Fremont, Hot Springs, Washakie, Big Horn, Park, Converse, Platte and Goshen counties. Typical fields of all ages were visited at a number of places within each county. The field studies will be continued in these counties and extended to others. They have been sufficiently inclusive, however, to indicate at this time the general situation with regard to alfalfa losses in the state. The results of the survey show that the chief losses are due to the failure of maintaining a profitable stand. The factors responsible for this are winter-killing and bacterial wilt.

The first type of loss is that resulting from the direct killing-out of large areas in a field by frost action during the winter or spring months. This is designated as winterkilling. Fields in

*No attempt was made during the course of the field studies to determine the losses in yield due to a soil deficiency of available phosphorus. Sufficient tests were made, however, to indicate that phosphorus deficiency is not responsible for the thinning out of stands. This should not be interpreted as underestimating the importance of adding phosphate to deficient soils. In fact, abundant evidence was obtained to support the conclusion reached by others that many fields in the irrigated sections of the state would respond to the addition of phosphate. Growers who are interested in this problem can obtain information on phosphate tests from their county agricultural agent, the sugar company field men or from the Department of Agronomy of the University of Wyoming.

which winterkilling occurs suffer heavy loss of stand during a single winter. This type of loss is much less prevalent than that caused by bacterial wilt. Associated with winterkilling is the formation of frost cankers on the crowns and tap roots of surviving plants. This injury to individual plants, which results in the formation of frost cankers, is spoken of as winter injury. Winter injury was found in a large percentage of the fields examined. It therefore occurs in many fields that have not suffered from extensive winterkilling. Winter injury alone is not a serious factor in reducing stands. Its chief importance lies in its relation to losses from bacterial wilt.

A second type of loss observed was that recognized by a gradual thinning out of the stand, accompanied by the stunting of a large percentage of the remaining plants. Most growers have in the past attributed this type of loss to winterkilling. Such is indeed not the case. The field studies supplemented by an extensive examination of diseased plants in the laboratory have shown conclusively that the bacterial wilt disease is primarily responsible for this gradual thinning out of stand which has been reported so frequently and which has been observed so commonly during the course of this survey.† In view of the general distribution of bacterial wilt and its frequent confusion with winterkilling the disease will be described and the known facts concerning it will be presented. It will also be pointed out to what extent the grower can reduce his losses from bacterial wilt. Winter injury plays such an important part in the life history of the wilt bacteria that it will be described first.

DESCRIPTION OF WINTER INJURY

Winter injury is easily recognized by the brown or black frost cankers which occur at the crown and at the upper portion of the tap root of affected plants (Fig. 1). If the cankers extend but a short distance into the tissues of the tap root the plant produces new growth which heals over the cankered area. The injured bark is then pushed out and becomes cracked. The dead bark, together

†Alfalfa plants affected with bacterial wilt have recently been received from Sheridan and Johnson counties. The disease has also been reported from Natrona County.



Figure 1. Two-year-old alfalfa plants seriously affected by winter injury which has produced dark-colored frost cankers at the crown. Injured tissues on plant at left are cracked open and are sloughing off. (Rootlets and stems removed to show cankers more clearly.)



Figure 2. Old Alfalfa plant cut apart to show hollow-heart. The center of the tap root has been decayed by bacteria and fungi which entered through frost cankers at the crown. Note the clean white appearance of the outer wood.

with some of the underlying tissues, is later sloughed off and the cankered area becomes roughened in appearance (1)‡. Plants affected with frost cankers are found abundantly in fields which have suffered heavily from winterkilling. They are commonly found in fields where winterkilling does not occur.

Frost cankers often extend to the center of the tap root. Just as in the case of more superficial cankers, the plant attempts to heal over the affected tissues. In this the plant is not always successful. Frequently the injured tissues in the center of the tap root are exposed by cracks extending to the crown (1). Bacteria and fungi enter the wounds and cause decay. These organisms are not capable of affecting uninjured plants, but are responsible for decay in tissues which have been injured and exposed (11). This eventually leads to a hollow-heart condition (Fig. 2). Plants affected with hollow-heart continue to produce vigorous shoots and may make nearly normal growth for several years. Eventually, however, they are killed.

DESCRIPTION OF BACTERIAL WILT

Foliage Symptoms. The foliage symptoms by which bacterial wilt can be recognized vary somewhat during the course of the season. Upon examination of severely diseased fields in early summer before the time of first cutting (Fig. 3) it will be noted that many of the plants have not survived the winter. Dead crowns are conspicuous. Others have decayed, leaving bare patches of soil exposed. Many of the remaining plants, although putting out new growth, are noticeably stunted. Varying degrees of stunting are seen (Fig. 4), ranging from severely dwarfed to nearly normal. The leaves on diseased plants are smaller than normal, yellowish in color and are rolled upwards. If hot weather has prevailed, wilting frequently occurs, particularly at the tips of the shoots, thus causing a drooping of the younger growth (Fig. 5). Wilting is usually more prevalent during the hotter months of late summer. As a result of the unusually high temperatures of June, 1930, wilting symptoms were conspicuous in many fields even at

‡Numbers in parentheses refer to the references cited at the end of this bulletin.



Figure 3. Four-year-old alfalfa field affected by bacterial wilt. Note bare spots, dead stubble, stunted plants and wilted tips. (Photographed two weeks before first cutting.)



Figure 4. Stunting of alfalfa plants by bacterial wilt. Plant on right nearly normal in size. (Photographed in early spring.)



Figure 5. Alfalfa plant showing wilting symptoms of bacterial wilt. Plants at extreme right nearly normal in size.

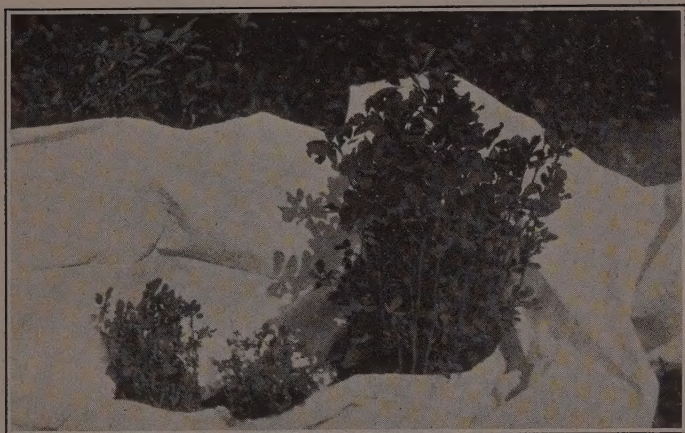


Figure 6. Stunting of alfalfa plant by bacterial wilt. Plants on left diseased, plant on right healthy. Note the dwarfed, bunched appearance of the diseased plants. (Photographed several weeks after the first cutting.)

that time. The disease usually occurs in patches, although at times it may be fairly uniformly distributed throughout the field.

Bacterial wilt can easily be recognized after the field has made several weeks' growth following a cutting. Dwarfing (Fig. 6) is the most conspicuous symptom at this time. The plants have a yellow cast and, as a result of the dwarfed habit, have a bunched appearance.

Root Symptoms. Although foliage symptoms vary to a considerable extent, an examination of the tap root will usually demonstrate whether or not a given plant is seriously infected. If the bark of the tap root is peeled back the woody cylinder of healthy plants is white while that of diseased plants is yellow or light brown in color. Occasionally reddish streaks are conspicuous. By cutting the tap root crosswise, these differences are even more striking. The wood in severely diseased plants is conspicuously discolored and contains deposits of brown material. This may be scattered through the wood or, more frequently, may occur in the form of rings in the outer layers of wood. The brown material

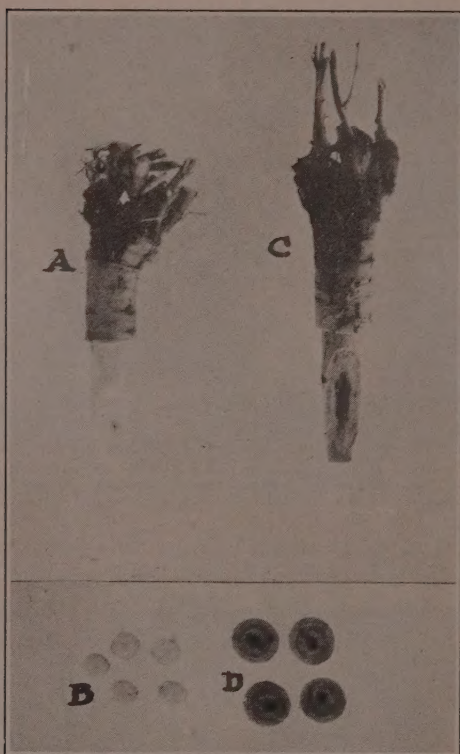


Figure 7. Root symptoms of bacterial wilt. A—Healthy plant with portion of bark peeled off and tap root cut across to show clean white appearance of the wood; B—Very young healthy alfalfa root shown in cross-section; C—Diseased plant with bark partially removed to show brown discoloration; D—Cross-section of diseased tap root, showing general discoloration and dark deposits of gum scattered throughout the section. (Plants in C and D also affected with hollow-heart, as evidenced by the dark discoloration in the center of the root. Slight evidence of hollow-heart is seen in healthy plant A.)

is a gum (6) apparently formed by the diseased plant. This gum, together with the bacterial masses, clogs the water vessels and causes the characteristic symptoms of stunting, wilting and eventually death. Fig. 7 illustrates the root symptoms of bacterial wilt.

Unless infection has occurred very recently, the disease can readily be recognized by careful observations of the foliage and tap roots of individual plants. The discoloration in the tap roots

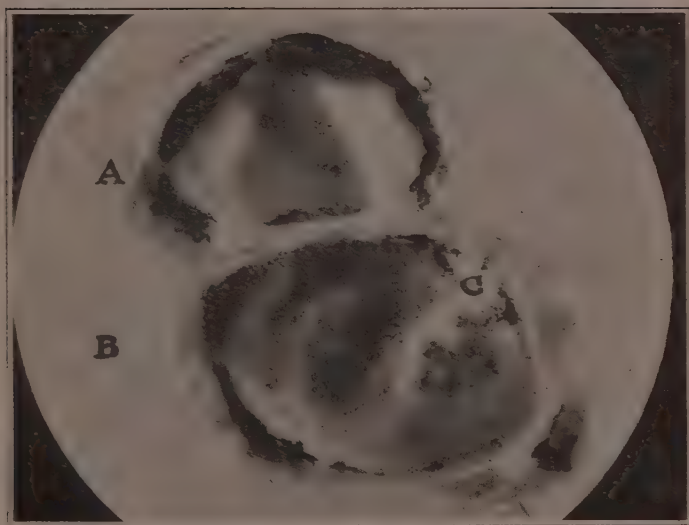


Figure 3. Microscopic appearance of the wilt bacteria. Portion of diseased tap root shown in cross-section. This was stained and magnified 575 times normal size. Two large water vessels are shown at the right of A and B. These are nearly completely filled with masses of bacteria. Numerous individual bacteria can be seen below C.

caused by the wilt disease should not be confused with the blackening in the center already referred to as hollow-heart (Fig. 2). The general discoloration due to bacterial wilt extends out into the roots and down to the extremity of the tap root, while the blackening due to hollow-heart is confined to the central portion of the wood at the upper end of the tap root.

THE CAUSE OF BACTERIAL WILT

Bacterial wilt is caused by *Apianobacter insidiosum* L. McC. a small rod-shaped bacterium (7 and 4). Microscopic examination of the tap roots and crowns reveals the bacteria within the tissues of diseased plants. They are found abundantly in the large vessels or tubes through which the plant is supplied with water (Fig. 8). The bacteria are particularly abundant at the base of shoots that have been affected by winter injury (2).

With the exception of sweet clover (4), no plant other than alfalfa is known to be attacked by the wilt bacteria.

Bacterial wilt is widely distributed over the United States and causes serious alfalfa losses in the Mississippi River Basin and in the irrigated sections of the west.

OVERWINTERING AND SPREAD OF THE BACTERIA

The wilt bacteria overwinter in the roots and crowns of diseased plants. It has been shown (4) that they can survive for five months in alfalfa hay and probably exist there much longer. There is no evidence that seed from diseased plants carries the bacteria.

The bacteria are released from diseased plants by any type of injury which exposes the infected tissues. Frost action, particularly at the base of young shoots, is largely responsible for this. Freezing injury cracks open the tissues and exposes the bacteria to the action of rain and irrigation waters (2). They are then readily carried by surface drainage or the flow of irrigation waters to healthy plants. Mechanical injuries of any kind may produce the same results as frost injury. Harrowing or disking diseased fields is undoubtedly responsible for the release and spread of the bacteria in some cases. The bacteria are likewise frequently carried from diseased to healthy plants by the knives of the mower (4 and 8).

ENTRANCE OF BACTERIA AND INFECTION OF PLANTS

The bacteria enter the plant through wounds. Winter injury cankers on shoots and tap roots are chiefly responsible (2). Injuries to the outer tissues of the plant caused by machinery or other mechanical means can likewise serve as the points of entry.

The bacteria develop in these outer tissues and push back into the water vessels where they are carried to nearly all parts of the plant. The plant responds to the action of the bacteria by the formation of a yellow gum which, as already noted, clogs the vessels

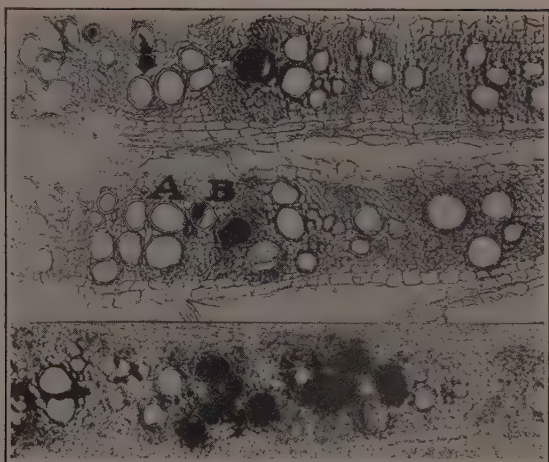


Figure 9. Microscopic appearance of diseased tap root showing plugging of the water vessels by bacteria and gum. This cross-section was stained and magnified 70 times normal size. Normal vessels A and plugged vessels B.

(Fig. 9). The plant later develops the characteristic symptoms and eventually dies. Dandelions and other weeds fill in the gaps caused by the death of the alfalfa plants (Fig. 10).

LIFE OF FIELDS IN WILT-INFECTED REGIONS

In view of the wide-spread distribution of bacterial wilt in Wyoming, it is important to know how long new seedlings of alfalfa may be expected to escape serious losses from this disease. This will depend primarily upon the age of the field when infection first occurs. It will also be influenced by the extent to which the disease is first introduced into the field and by the rate at which the disease spreads following its introduction.

Bacterial wilt is rarely observed before the field is two years old (8). It may appear at any time thereafter. New seedlings which are favorably located with reference to diseased fields may escape infection for a number of years. The conditions under which irrigated alfalfa is grown in this state favor the chances for an early infection.



Figure 10. Twelve-year-old alfalfa field overrun by dandelions following thinning out of stand by bacterial wilt.

Losses from wilt are much heavier when the first appearance of the disease is general than when it occurs in only a small area of the field. The disease commonly first appears in restricted areas of the field where conditions are more favorable for its development.

Once the disease becomes established in a field the losses vary according to the rapidity of spread. Every diseased plant is a possible source of bacteria with which healthy plants may become infected. Diseased plants usually die during the second year following infection (8). Stunting precedes death, consequently it is entirely possible (when infection occurred during the second year) for heavy losses to occur during the third and fourth years in the life of the field. Heavier losses may be expected during each of the following years. It appears questionable then whether the average grower can be assured of maintaining a profitable stand longer than five or six years.

FACTORS AFFECTING INTRODUCTION AND SPREAD OF WILT

The losses from bacterial wilt vary (as has just been noted) with the time and extent of the first infection and with the rate of spread after the disease has become established. It is, therefore, important to know what factors are responsible for the introduction and spread of this disease within a field.

Winter Injury. It has already been pointed out that frost action is largely responsible for the release of the wilt bacteria from diseased plants and for providing openings in healthy plants through which the bacteria can enter. Consequently, anything which favors the appearance of winter injury likewise may affect the prevalence of bacterial wilt. It is recognized (8) that a late fall cutting followed by an early winter increases the danger from winter injury. Heavy pasturing late in the fall is probably also responsible for an increase in winter injury.

Water Relations. Bacterial wilt is more abundant under relatively wet conditions. The disease will never be of importance on dry-land farms* of the state where alfalfa is grown for the seed crop. In irrigated sections the disease is more abundant in low spots of the field where irrigation water collects or where drainage is poor. This was well illustrated by a small field upon which irrigation water had frequently been turned in to avoid waste. This field, which had been subjected to seven irrigations, was severely diseased while a nearby field of the same age was relatively free of the disease.

The surface flow of irrigation waters or of rain is chiefly responsible for the washing of bacteria from injuries in diseased plants and for the spreading of bacteria to new seedings or to healthy plants within a diseased field.

Cultivation. The practice of disking or harrowing poor stands of alfalfa has been advocated for control of weeds and for increasing the productivity of the field. The use of disks or harrows in this manner undoubtedly causes a considerable amount of

*Bacterial wilt has never been observed in the dry-farming area of this state.

injury to the plants. These wounds, like those resulting from frost action, provide points of entry for the wilt bacteria. It is also possible that the use of such implements aids in spreading the disease. Thus, while temporary benefits may be derived from this farming practice, it is very likely to be followed by increased wilt infection in fields that have been reduced in stand by this disease.

Cutting. There is considerable evidence (4 and 8) that bacterial wilt may be introduced and spread by the knives of the mower during cutting operations. Spread of the bacteria in this manner is more likely to occur if the cutting is done while the plants are wet with dew or rain. The knives serve to release the bacteria from diseased plants and to carry them to healthy plants where they enter through the cut ends of the shoots.

Variety of Seed. The prevalence of the disease within a field varies considerably with the kind of seed used. Different varieties of alfalfa vary in their resistance to the disease. Tests at the Nebraska Station (8, 9) indicated that Baltic, Cossack, Canadian Variegated, Grimm, Le Beau, Hardigan, Peruvian and a number of strains of common alfalfa were susceptible to wilt. Certain selections of Provence and Turkestan were either quite tolerant or resistant to wilt. Hardistan (5) offered considerable promise in respect to wilt resistance. Ladak (3, 9, 10) has also appeared promising in preliminary tests.

CONTROL OF BACTERIAL WILT

There is no method by which bacterial wilt can be completely controlled at the present time. There are, however, a number of methods which can be used to reduce the losses from this disease.

Choice of Seed. Complete control of bacterial wilt must undoubtedly be sought in the discovery or development of alfalfa varieties which are highly resistant or immune to the disease. As already indicated, some progress has been made in this direction. Hardistan, which appears very promising, is not available on the market. There is undoubtedly a considerable variation between

different lots of Turkestan seed offered on the market. A grower desiring to test Turkestan should do so on a small scale.

An effort is being made to discover old fields within the state which, although located near diseased fields, are still maintaining excellent stands. One such field has been found. The occurrence of similar fields in other sections should be reported to the county agent or to the Department of Agronomy of the University of Wyoming. Seed from such fields will be tested for resistance to wilt.

Until a resistant or immune variety is available it is advisable to use a good grade of northern-grown common alfalfa seed. Grimm, although a hardy variety, is susceptible to bacteria wilt.

Location of New Seedings. Whenever possible new seedings should be so located that they will not receive irrigation or drainage water from old fields. New seedings adjoining or located near old fields are more subject to early infection of wilt than if situated some distance away. Irrigation waters are primarily responsible for the spread of the wilt bacteria.

Carrying Out a Rotation. The practice of ploughing up old alfalfa fields that have become unprofitable through loss of stand and putting them back into alfalfa immediately is carried out on some ranches. In such instances it is not possible to kill all of the old plants. If the field has thinned out as a result of bacterial wilt (as is usually the case) these old plants provide an abundant and convenient supply of bacteria for the infection of young seedlings throughout the field. The disastrous effects of this practice were noted in a field of 120 acres in which 60 per cent of the young plants were infected with the wilt bacteria during their second year. If it is necessary to re-seed an old field it should be grown for two or three years with crops that can be cultivated to destroy all old plants before seeding with alfalfa.

Careful Irrigation. Careful irrigation is highly important in reducing losses from bacterial wilt. Excessive amounts of water at one time or too frequent applications of water favor the prevalence of the disease. Wilt is likely to be more serious in low, poorly-drained spots of the field.

Avoiding Mechanical Injuries. Inasmuch as the wilt bacteria enter the plants through wounds any farming practice which causes injury to the crown or tap root exposes the field to more severe losses from the disease.

Careful Mowing. The wilt bacteria are spread from diseased to healthy plants during cutting. The method of cutting alfalfa fields is therefore important. Each field should be cut separately. The younger fields should be cut first and the older fields last. Where the same field contains seedings of different ages each section should be handled separately. Mowing should be done when plants are neither very dry nor excessively wet. If the plants are too dry there will be a heavy loss of leaves. Mowing when the plants are very wet from dew or rain is, however, not necessary and should be avoided since this aids in the spread of the bacteria and favors their introduction into the cut stems.

Reducing Winter Injury. Every effort should be made to have the field in vigorous condition in the late fall. This will reduce the amount of winter injury and consequently will help avoid heavier losses from bacterial wilt. Fields should not be cut late in the fall. Likewise they should not be heavily pastured late in the season. The use of northern-grown hardy seed will, to a certain extent, reduce the losses and injuries which occur during the winter months.

Feeding Hay from Diseased Fields. Hay from diseased fields should not be fed where it can be easily distributed to young fields. Surface waters running over diseased hay are probably responsible in some cases for introducing the bacteria into new seedings.

SUMMARY

Alfalfa is Wyoming's most important crop. Serious losses have been frequently reported from the irrigated sections of the state. A field survey was begun in 1930 to determine the nature and cause of these alfalfa losses. Although the survey has not been completed, the work thus far carried out shows that the chief losses are due to the failure of maintaining a profitable stand. The bacterial wilt disease caused by *Aplanobacter insidiosum* L. McC. is primarily responsible for this. Winterkilling also causes some loss of stand. Frost cankers (winter injury) were commonly found in the majority of fields examined.

Alfalfa growers have commonly attributed the losses from bacterial wilt to winterkilling. In view of this confusion bacterial wilt is described and illustrated. Winter injury, which plays an important role in the life history of the wilt bacteria, is also illustrated and described. The known facts concerning bacterial wilt are brought together and it is pointed out to what extent the grower can reduce his losses from this disease.

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